COMBINING OF BIOMASS PRODUCTION FOR ENERGY WITH AGROFORESTRY – EXPERIENCE FROM SHORT ROTATION COPPICE WITH POULTRY BREEDING

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Abstract

The aim of our contribution is to present selected results and conclusions from long term monitoring of selected production and environmental parameters in small agroforestry system which consist of poplar and willow short rotation coppice (SRC) for production of energy biomass combined with poultry breed for self-provision of woodchips and eggs/meat. Mostly positive trends were found of monitored soil parameters in topsoil (5-15 cm) under SRC with poultry after 17 years including stable or increasing levels of C_{ox}, pH, P, K, Ca, Mg despite no fertilization being applied and tree biomass being removed (5 harvests). Additionally, closed canopy of SRC improved welfare of poultry by lowering temporal variations of air temperature and humidity especially in hot days and providing shelter against raptors. Combining poplar/willow SRC for biomass production with poultry breeding can be recommended for its multilateral positive effects on soil, microclimate, welfare and adaptation/mitigation effects.

Keywords: short rotation coppice; grassland; poultry; soil; microclimate; animal welfare

Introduction

Biomass is the most important renewable source of energy in the Czech Republic and whole EU. It covers about 60% of the renewables contribution to total energy consumption similarly as in many Central European Countries. The development of different forms of biomass production is also an important mitigation and adaptation measure in policies of EU countries including energy, environment and agriculture (reduction of GHG, soil erosion control, biodiversity, etc.). Short rotation coppice (SRC) with fast growing trees (poplars and willows) is currently the most widespread and successful "energy crop" in Czechia thanks to good and stable yields, low-input agronomy and good fuel characteristic of their biomass. Currently there are approximately 3,000 ha of these plantations in the Czech Republic (Hudáček 2017). Most of them were established by small landowners for self-provision of firewood and/or woodchips production for local and regional power and heating plants. There are over 650 such growers with plantation sizes ranging typically between 0.5-2 ha, of which many are relatively well suited for agroforestry utilizations (fenced, close to farm). SRC plantations are currently established mostly with poplar clone J-105 (*Populus nigra* × *P. maximowiczii*), but many new species and varieties are tested of poplar, willow, alder, ash or paulownia, which may be used also for non-energy purposes (wood processing, basketing, bee-feeding). Some SRC plantations have been established for their environmental effects such as wind and water erosion control, animal welfare etc (Weger 2008).

Agroforestry has been practiced from the beginning of agriculture in all of Europe; however, currently it is not a common land use system in the Czech Republic and has no recognition in Czech legislation. Traditional agroforestry practically disappeared during the era of collective farming during the 20th century, except for small remnants. Currently, to our knowledge, there

are no existing modern agroforestry systems (e.g. alley cropping) for timber production yet, however, potential for producing quality timber (e.g. wild cherry, walnut) and wood biomass exists.

The rapid development of short rotation coppice systems during the last decade demonstrates the growing potential and interest in establishment of these systems in agroforestry schemes. One of the easiest possibilities for farmers is the combination of those plantations with poultry.

The aim of our contribution is to present selected results and conclusions from long term monitoring of selected production and environmental parameters in small agroforestry system which consist of SRC combined with poultry breed both for self-provision of woodchips and eggs/meat.

Materials and methods

The experiment was established on a farm situated in Nová Olešná near Jindřichův Hradec, Southern-Bohemian region. The site is situated 560 meters above sea level, there are mean precipitations of 541 mm and mean temperature is 7.5 °C. The soil type is evaluated as kambizem according to Taxonomic classification of agricultural soils of the Czech Republic (Němeček 2001), Cambisol according to WRB (IUSS Working Group WRB 2015) and Inceptisol according to Soil Taxonomy (USDA-NRCS 2010) with soil pedo-ecological unit numbers 7.29.51. and 7.32.14 (Němec 2001).

The experimental site is divided into three resp. four different plots on a total area of 0.6 ha (Figure 1). The short rotation coppice part consists of the clone test of poplars and willows (0.2 ha), plantations for firewood/woodchips (0.15 ha) and stool bed for cuttings (reproduction material) on 0.1 ha and a garden used for small-scale vegetable production (0.1) including facilities for small scale poultry farming.

Figure 1: Areal picture of the experimental agroforestry system in Nová Olešná (left) and picture of cattle pasture (right) adjacent to SRC visible on left. ALS plots/parts: A) poplar alley and vegetable garden with henhouse, B) poplar/willow experimental SRC clone test (middle and left), C) poplar/willow SRC for energy biomass (right) and D) poplar stool bed; bullets show soil sampling points (SRC1-3, L1-3) of 2017 soil analysis (comparison of SRC and pasture).

Agroforestry systems (AFS) were established gradually since 1999 to 2004 starting with SRC clone test (36 genotypes), SRC plantations for biomass and planting material and ending with introduction of chicken breed to the whole system together with vegetable production garden. Agroforestry systems (all plots) were fenced and they are surrounded from three sides by grasslands (cattle pasture on western-southern side, hay production on eastern side) and by tree vegetation (Ash, Elm and Linden) from the north. Pasture (14 ha) was grazed repeatedly by cattle herd consisting usually between 55-65 cows and calves. Water, hay and additional feeding was provided accordingly on pasture.

Poultry consisted of typically 20-30 hens with one cock and several specimens of ducks, turkeys and geese over the years, depending on the farmer family needs and other factors, e.g. prey by fox and marten. A henhouse with water and feeder is located inside in vegetable garden plot. Poultry has been fed by locally produced cereals and some commercial pellets ad libitum. The AFS and surrounding grasslands has been managed and owned by Mr. Bartoš family (Figure 2).

Figure 2: Poultry in poplar willow clonal SRC test (right: rotten wood removed by chicken).

During the whole experiment we have been monitoring the following production and soil parameters: biomass yield, biometrics, soil changes and nutrients content (pH, Cox) air and soil temperature in the SRC and on grassland.

The goal of soil monitoring in Nová Olešná is to evaluate changes of selected soil characteristics – nutrients (P, K, Mg, Ca – Mehlich III), soil reaction (pH in water) and humus (C_{ox}) in SRC with willow and poplar as part of monitoring of selected experimental SRC plantations on agricultural land. Soil samples have been taken from topsoil (5-15 cm) after each harvest. Three to five soil sub-samples were collected and mixed into one composite sample to represent individual SRC plot or part.

In addition, in 2017 three soil samples were taken from adjacent cattle pasture and SRC using same methodology and analyzing same characteristics as in long term monitoring. Samples in SRC (1-3) represent different managements and tree composition e.g. poplar stool-bed (1-2 year rotation), poplar and willow clonal test (3-year rotation) (see bullets in Figure 1).

Air temperature and humidity at 0.5 m above the ground, soil temperature at 0.25 m below ground and average soil moisture in rooting zone (0.1–0.5 m below ground) have been measured automatically in grassland and SRC.

Results and discussion

Biomass yield of the best 5 clones (out of 36) was 9.04 t DM/ha/year on average from three harvests (9 years) and 17–20 t DM/ha/year in the third harvest. Best clones include natural hybrids of autochthonous willows (*Salix* × *smithiana*, *S.* × *rubens*). In the biomass (SRC) plantation poplar clone J-105 (*Populus nigra* × *P. maximowiczii*) yielded 14.6 t DM/ha/year in the third 3-annual harvest e.g. in 9th year (Weger 2008).

Mostly positive changes were found of monitored soil parameters in topsoil (5-15 cm) under SRC after 17 years. All monitored parameters increased despite the fact that any fertilization was used in 17 years (Figure 3). Similar “improving” trends were found when comparing top soil from SRC with poultry and grassland with cattle in 2017 analysis - except pH which was lower in SRC (Table 1).

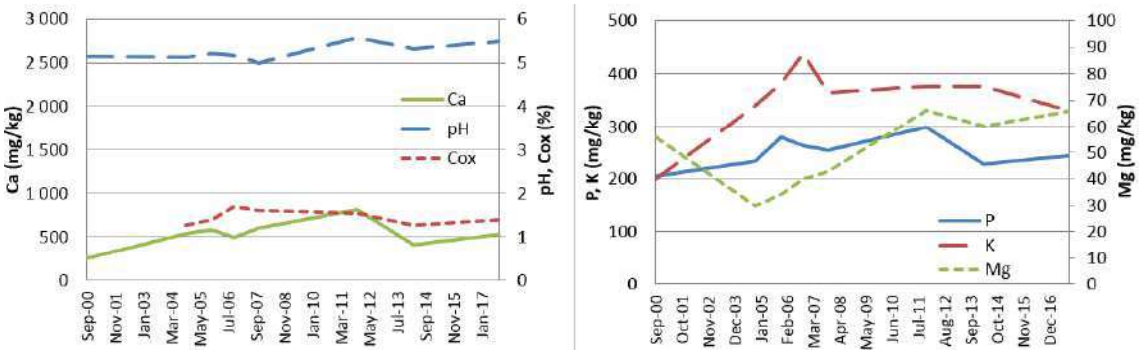

Figure 3: Changes of selected soil parameters in topsoil (5-15 cm) under poplar and willow SRC with poultry breed in Nová Olešná after 17 years (Biomass harvested in 3-year rotations).

Table 1: Results of soil analyses (incl. ANOVA) from topsoil (5-15 cm) in poplar and willow SRC with poultry breed and adjacent grassland (cattle pasture) in 2017 (Weger and Bubeník 2017).

Site - plot	pH	Ca	Mg	K	P	C_{ox}
	H_2O	(mg/kg)				[%]
Grassland (L1)	5.53	407	49	100	195.9	0.83
Grassland (L2)	5.59	487	50	180	131.4	0.92
Grassland (L3)	5.61	440	53	344	192.8	1.03
SRC 1 (poplar stoolbed)	5.50	533	58	352	227.3	1.31
SRC 2 (willow clone test)	5.49	539	66	315	210.2	1.25
SRC 3 (poplar clone test)	5.47	524	73	323	294.6	1.65
Grassland Ø	**5.58 a**	**445 a**	**51 a**	**208 a**	**174 a**	**0.92 a**
SRC Ø	**5.49 b**	**532 b**	**67 b**	**330 a**	**244 a**	**1.43 b**
p (ANOVA, Tukey-HSD)	0.0246	0.0209	0.029	0.169	0.100	0.025

Regarding climatic efficiency, SRC plantation in Nová Olešná with closed canopy in comparison with grassland have lower the midday air temperatures (by 4-5 °C on extremely hot days) and also the soil temperature based on previous results (Šír et al. 2009).

SRC with closed canopy provides shelter for poultry against raptors, but still they have been threatened by foxes and martens (Bartoš, pers.comm.). This can be solved by installation of proper fencing or by locking poultry in henhouses before dawn because those small terrestrial predators are mainly nocturnal.

Conclusion

1. Mostly positive trends were found of monitored soil parameters in topsoil (5-15 cm) under poplar and willow SRC with poultry breed in Nová Olešná after 17 years. All parameters have increased despite that any fertilization was used and trees were harvested 5 times.

2. "Better" soil parameters (C_{ox}, Ca, Mg) were found in top soil of SRC with poultry when comparing with grassland (cattle pasture) in 2017.

3. SRC with closed canopy greatly improves welfare of chicken breed by: i) lowering temporal variations of air temperature and humidity especially in hot days, ii) providing shelter against raptors.

4. Widespread use of SRC may be welcomed also for mitigation of climate change thorough carbon sequestration in topsoil by humification of leaves litter and in below ground soil by root biomass.

5. Combining poplar/willow SRC for biomass production with poultry breeding can be recommended for its multilateral positive effects on soil, animal welfare and landscape climatic efficiency.

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